Exploitation of radioactive beams
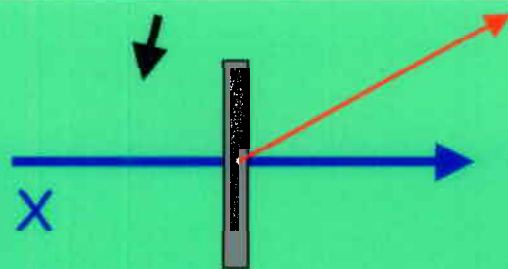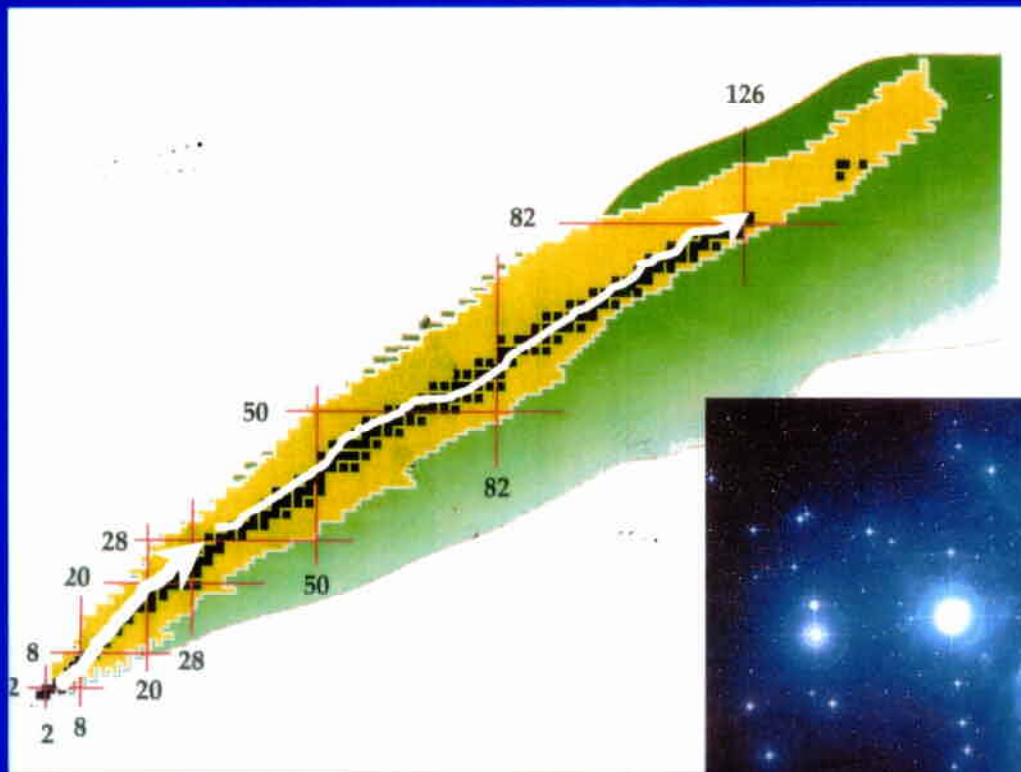
Stopped RIB:
Measure Mass,
$T_{1/2}$, decay – e.s.
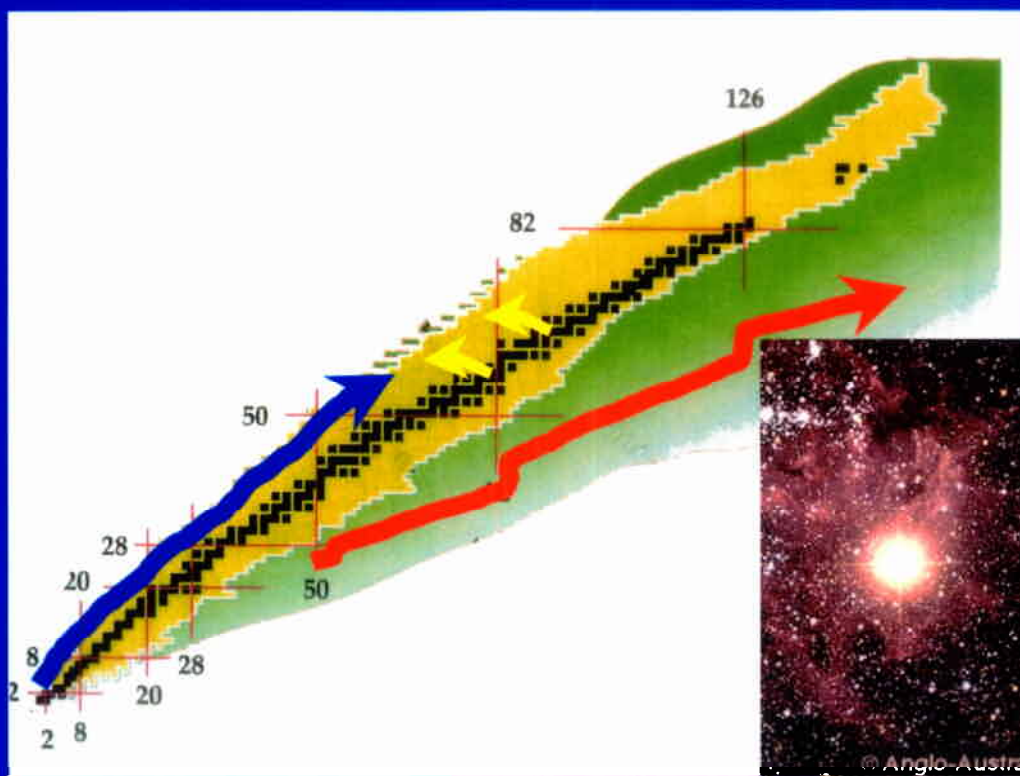
126

82

82

50

50

28

20

28

8

20

2

2   8

X
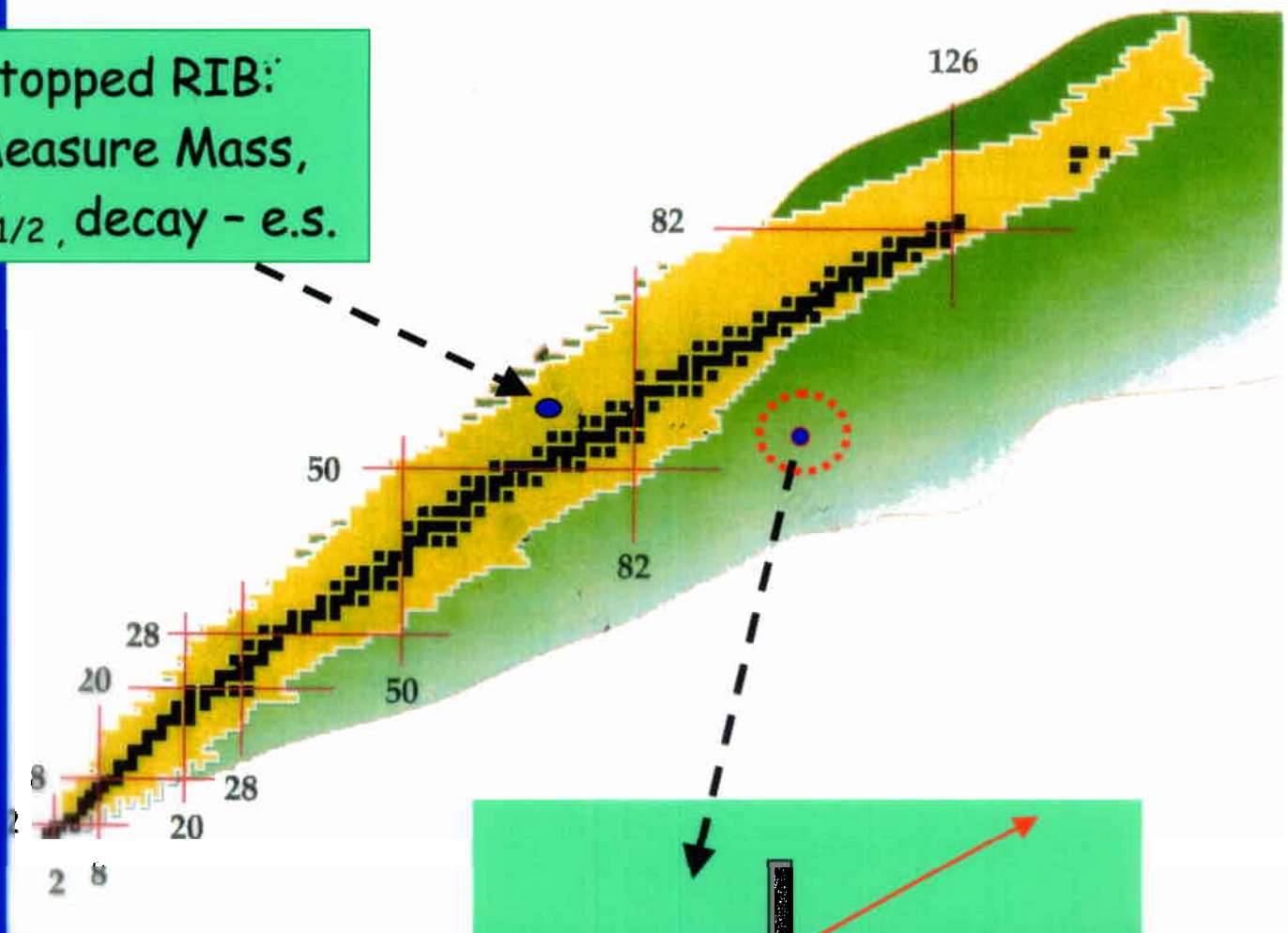
Reactions   A(x, a)B
Extend our knowledge of
nuclei around X

A(x, a)B ⟹ Nuclear physics
          ⟹ Astrophysics reasons

Main sequence steady burning

Explosive burning

Explosive burning

126
82
50
28
20
8
2
2 8
20
28
50
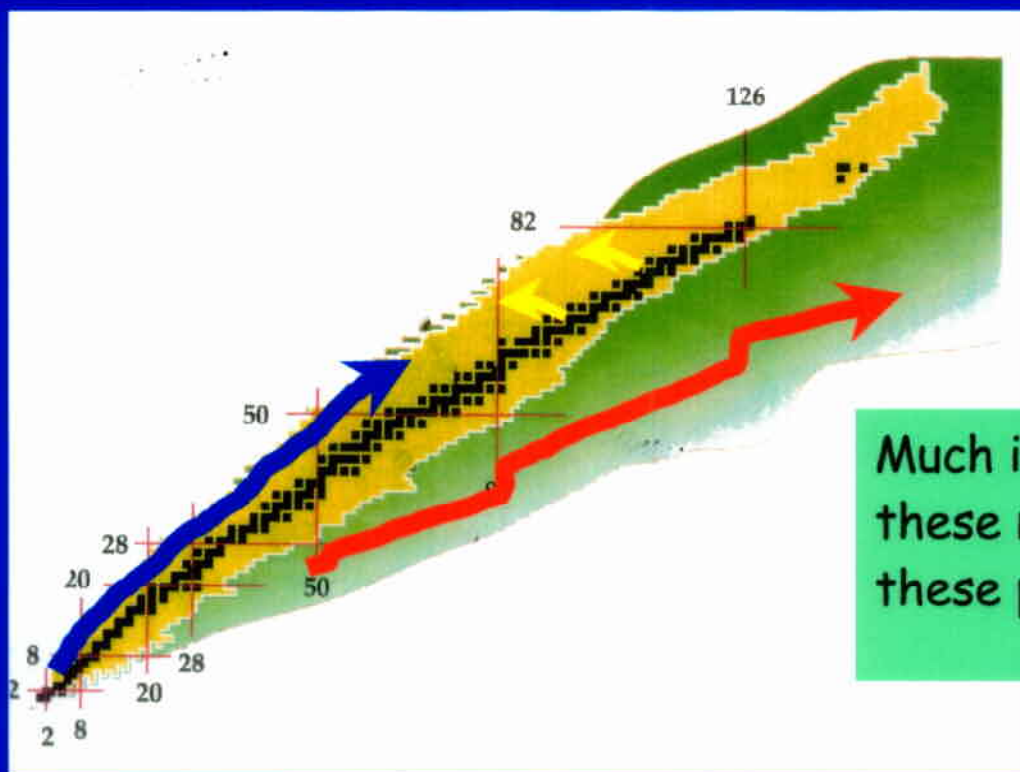
Much is unknown for these nuclei on these paths

Needs:
Basic properties: masses, half-life, excited states,
Reaction rates for alpha, proton, neutron induced reactions

e.g. (p, γ), (α, γ), (p, α), (α, p), (n, γ)

Two procedures:
a) Direct method
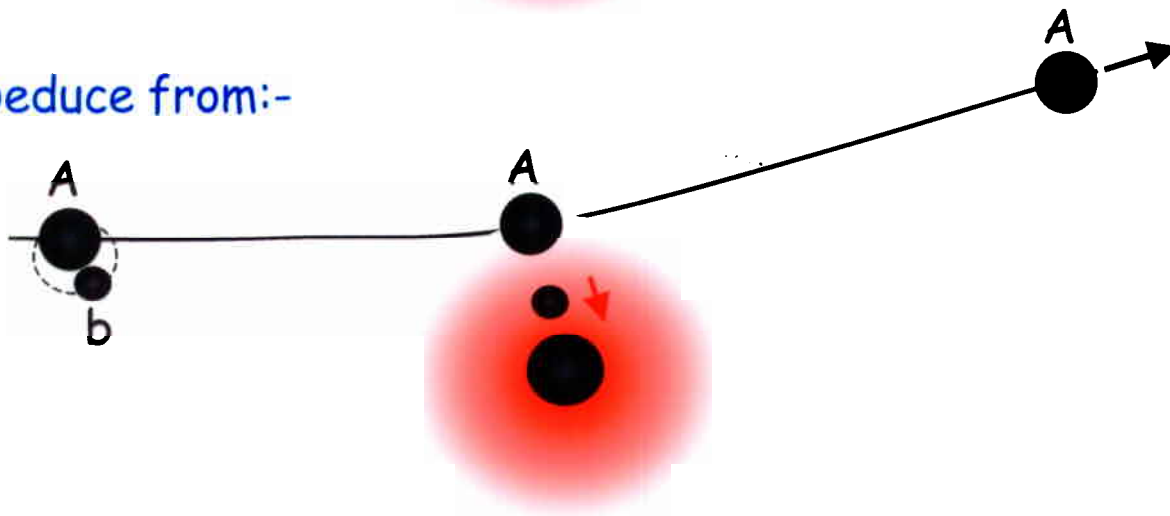   Produce the RIB, X, and use inverse kinematics – p(X,Y)

b) Indirect method
   Study X(n, γ) by (n –A)(X, γ)A

Quasielastic transfer reactions to deduce low energy charged particle reactions

Reaction of interest

Deduce from:-

Relavent points:-
- Assume Quasielastic – A just a spectator
- Assume 2*2 body reaction
- Off-shell components involved
- Assume no A+b internal wavefuntion distortion
- Assume cluster nature A+b
- Assume other reaction mechanisms small
- Problem finite energy resolution deduced for b + target

Example:

Reaction of interest $d + {}^6Li \longrightarrow \alpha + \alpha$

Quasi-elastic reaction

$(\alpha+d) + {}^6Li \longrightarrow (\alpha) + (d+{}^6Li)$
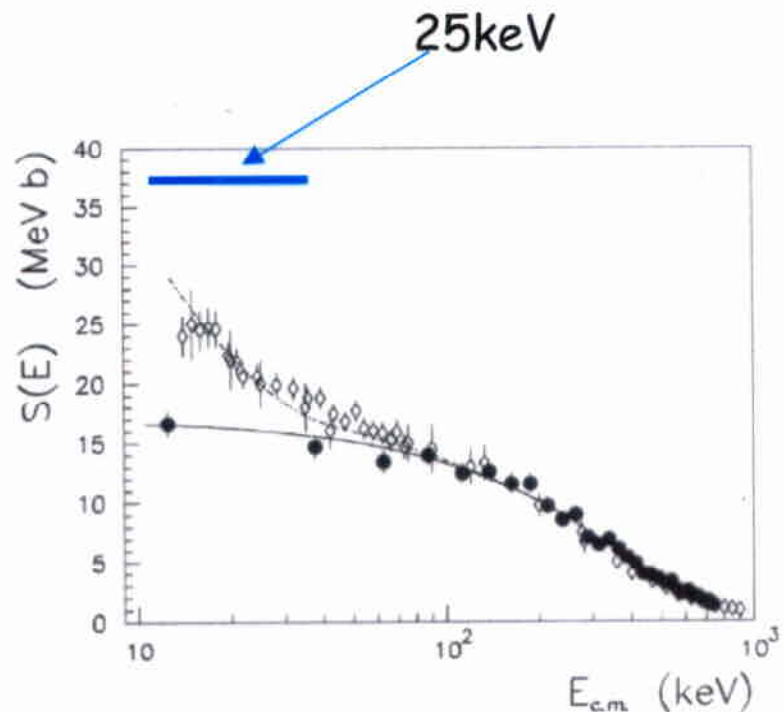
$\longrightarrow \alpha + \alpha$

MeV ${}^6Li$
Projectile

${}^6Li$
target

C Spitaleri et al 2001

$d + {}^6Li \rightarrow \alpha + \alpha$

25keV

- ${}^6Li \rightarrow d+\alpha$ not largest component
- Distortion of ${}^6Li$ wavefunction (initial state interactions)
- Other reaction mechanisms
- Finite energy resolution ~ 25 keV

To gain greater confidence in this method, investigation of the complete reaction phase space is needed to understand, in depth, the reaction mechanism.

An interesting example:-

$$d + {}^{15}N \rightarrow p + {}^{16}N : \text{ Fuchs et al}$$

$$(p+n) + {}^{15}N \rightarrow (p) + {}^{16}N$$

$$n + {}^{15}N \rightarrow {}^{16}N ?$$

$$n + {}^{15}N \rightarrow n + {}^{15}N$$